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Information, Technology, and the Center of Gravity

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THE AMERICAN WAY OF WAR is characterized by the use of overwhelming force and a search for technological advantage.[1] This appears to be a logical approach, given a political need to limit the duration of a conflict and minimize casualties. This style of warfare, however, is not applicable to every type of conflict.[2] Although technology has certainly enhanced the conduct of war in many ways, it remains only a tool, useful in certain applications. In addition, the United States cannot be assured of overwhelming strength or technological advantage at the commencement of hostilities. Therefore, U.S. military officers must reflect carefully on the roles and limitations of technology in warfare; the concept of "center of gravity" can help.

Technology is improving the methods of obtaining and disseminating information in a way that influences the conduct of military operations as well as their command and control. New information systems have improved target acquisition and the ability to attack an enemy's infrastructure. As a result, many analysts have suggested the imminence of a revolution in military affairs brought about by the integration of information.[3]

Clearly, technology and information have had at least an evolutionary influence on warfare and virtually every other aspect of Western society. Yet in the rush to exploit the new technologies, it is easy to lose sight of other factors that create an advantage on the battlefield. Three elements—technology, ideas, and societal change—are at the heart of true revolutions; in turn, they each represent

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sets of choices. And while technology may be pursued to create a force multiplier, it also can limit opportunity for the development of new ideas or for societal change.

Unfortunately, the success of the United States in the Persian Gulf War has reaffirmed the appeal of the technological solution. The lessons of the Vietnam War have been lost in the desire to embrace this success. What should have been learned in Vietnam is that the nation's technological advantage is not always decisive; that tactical success does not always ensure victory; and that planning efforts must be focused.

One way to achieve such focus is the concept of the "center of gravity"—defined in the U.S. military as "those characteristics, capabilities, or localities from which a military force derives its freedom of action, physical strength, or will to fight."[4] Specifically, American joint doctrine suggests that "the centers of gravity concept is useful as an analytical tool, while designing campaigns and operations, to assist commanders and staffs in analyzing friendly and enemy sources of strength as well as weaknesses and vulnerabilities."[5]

Properly applied, the center of gravity idea can concentrate planning efforts.[6] In the United States, the value of the concept has been obscured by the drive to apply overwhelming force, and also by differences in missions and perceptions among the services. In addition, the proliferation of information technologies has led to the impression that information is itself a center of gravity, which has in turn confused both the role of information and the center-of-gravity concept. Information seems to have been transformed from a means to an end. As a result, military doctrine about the role of information technologies and the center of gravity is poorly understood and awkwardly applied, if at all.

The question to be examined, therefore, is, what can the United States do to fight better? The answer is twofold. First, the *limitations* of information and technology as tools of war need to be recognized and their risks assessed. Secondly, *planning* must acknowledge that overwhelming force may not always be possible. In that connection, the utility of the center of gravity for planning warrants exploration.

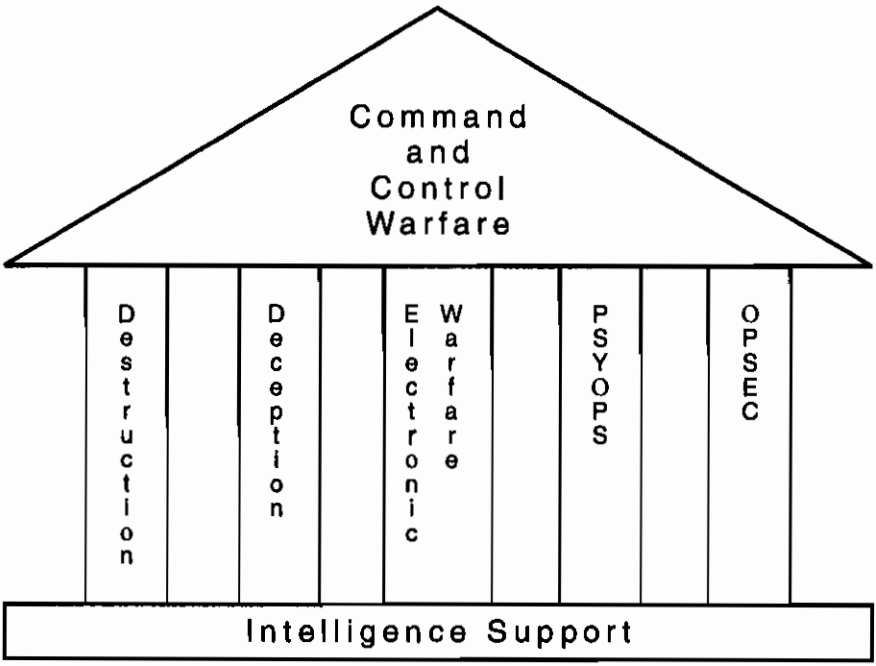
Tools of War: Information and Technology

The rapid growth of information technologies and the promise of improved command and control have caused a reexamination of the role of information in warfare. The ideal of "information dominance"—that is, the ability to see, hear, and understand the enemy's command and control systems, intelligence sources, and sensors better than he understands ours—has produced a new discipline known as "information warfare."[7] Information warfare can best be defined as "actions taken to achieve information superiority in support of a national military

strategy by affecting adversary information and information systems."[8] This definition also encompasses other, more traditional military terms, such as intelligence, which is "information and knowledge about an adversary obtained through observation, investigation, analysis, or understanding."[9] Whereas intelligence is a process meant to elicit knowledge, information warfare represents specific offensive and defensive actions designed to exploit information. Information warfare, then, is a broad concept that integrates many elements of modern warfare and in fact transcends military applications.

Components and Models of Information Warfare. Information warfare is typically considered to have a purely military subset, "command and control warfare." That component, in turn, is viewed as resting upon five "pillars": destruction, deception, electronic warfare, psychological operations (PSYOPS), and operational security (OPSEC). None of these elements, however, represents a particularly new aspect of warfare; they have been exercised in one form or another for decades, or in some cases centuries. Figure 1 depicts the conventional command and control warfare hierarchy.

Figure 1
Components of Command and Control Warfare



Source: Chairman, Joint Chiefs of Staff, Memorandum of Policy (MOP) 30

Table 1

	Toffler	Lind et al.	Hammes
Precept	Military change parallels way of making wealth	Military change occurs with shifts in technology or ideas	Military change occurs with shifts in societal structure
Historical progression	Waves: 1) Agricultural 2) Industrial 3) Information	Generations: 1) Massed manpower 2) Massed firepower 3) Maneuver 4) Terrorism-like wars	Generations: 1) Massed manpower 2) Massed firepower 3) Maneuver 4) Netwar
Drivers of change	Information-based economy	Technology and ideas	Political, economic, and social factors

In contrast, information warfare contains not only the components of command and control warfare but also a number of others: intelligence-based warfare, electronic warfare, psychological operations, "hacker" warfare, economic information warfare, and "cyber-warfare."[10] Of these, only certain elements of economic information, "hacker," and "cyber" warfare can be said to be new; the others are extensions of existing practice. They certainly do not alter the role of information, whether as a means or a tool. In addition, the elements that are new are probably best employed prior to the start of a conflict, most likely by nonmilitary agencies, either to avoid or shape the conflict; that is, they are not properly *warfare* at all.

What aspect of information exploitation *has* changed? The answer lies in the potential "revolution in military affairs" brought on by new technologies and advances in computer science and communications.[11]

Three principal models have emerged that attempt to explain the roles of information and information systems in warfare. These models (summarized in

Table 1) all suggest a historical progression by which a new form of warfare has been created by a specific catalyst.

In a model proposed by Alvin and Heidi Toffler, information technologies are creating a "third wave" of warfare (in contrast to the preceding "agricultural" and "industrial" waves). The Third Wave's distinguishing characteristics are "brain-force," proliferation of technologies, nonlethal weapons, and knowledge-based warfare.[12] For the Tofflers, the type of warfare employed by a society directly reflects its means of producing wealth; their model suggests that since information is the basis for wealth in a number of societies, it is natural that information-based warfare has evolved. The catalyst of change, therefore, is a shift in the economic base of society.

A similar approach is the "fourth generation" model proposed by William S. Lind and others. According to it, warfare in the modern era has progressed through three generations—tactics of line and column (massed manpower), tactics of fire and movement (massed firepower), and nonlinear tactics of maneuver.[13] The Lind model suggests that not economic forces but either technology or ideas create generational shifts. Elements of continuity are likely to carry over into the Fourth Generation, particularly the goal of defeating an enemy from within instead of through physical destruction.[14] The most significant shift, however, occurs because Fourth Generation warfare accentuates the nonlinear nature of the Third Generation—that is, the distinction between war and peace will be further obscured and conflict will be dispersed over an even larger battlespace.[15] A non-Western, idea-based generation of warfare, including war that resembles terrorism, is in this view a possible alternative to the Western, technology-based Fourth Generation.

An extension of the Lind model has been proposed by Thomas X. Hammes, who argues that a Fourth Generation has indeed arrived but is driven not by technology or ideas but by the synthesis of political, social, and economic changes.[16] In place of Lind's vision of terrorist wars spawned by ideas, Hammes foresees a future of "netwars"—"societal-level conflicts waged in part through internetted modes of communications."[17] In this context, Netwar takes economic, political, and social forms. The distinguishing feature of this new type of conflict, however, is the specific targeting of information itself, as well as of communications systems.[18]

Clearly, all three models suggest that a revolution in warfare is being caused by information integration, but they involve different catalysts—technology, ideas, or societal change. The Tofflers, Lind, and Hammes agree that all generations of warfare coexist, because technological transformation does not occur everywhere simultaneously. As a result, technological influences are spread over time, and high-technology solutions are not applicable to all forms of conflict. Information, therefore, should not be seen as a "new" element that overlaps the

different "waves" of warfare but rather as a component of any and all of its generations. The issue remains whether the technological changes that are now integrating information in warfare are in fact revolutionary.

Revolution or Evolution? Although the defining criteria of a revolution in military affairs, or RMA, vary between analysts, a revolution can be said to comprise four elements: technological change, systems development, operational innovation, and organizational adaptation.[19] The new information technologies reflect a high level of technological change and systems development, and they can have an operational impact, but the effect does not necessarily amount to operational *innovation*. Clearly, the new technologies offer the ability to perform tasks better than in the past, but they still collectively represent only a limited change to the operational or tactical imperative to place ordnance on a target.

In addition, when organizational adaptation lags behind technological innovation—as it often does, and is now the case for information warfare—what occurs is enhancement of process, not revolutionary change. The new technologies improve the ability to locate, track, identify, target, and destroy targets over increasing distances; "revolution," however, incorporates a "recognition, over some relatively brief period, that the character of conflict has changed dramatically, requiring equally dramatic—if not radical—changes in military doctrines and organizations."[20] To date, information technologies have not produced such operational innovation: information techniques are too broad, and the truly new capabilities lie outside military circles. What, then, is the real role of information and information systems?

Technological changes in this field do offer a number of significant enhancements. First, improved information integration speeds the decision-making cycle by processing and distributing information more quickly, creating thereby an advantage that can be exploited. Second, information is a force multiplier, in that it allows more efficient allocation of (ever scarcer) assets and improves target acquisition. The new systems provide fuller knowledge of enemy hardware, troop concentrations, and of the environment and terrain. At the tactical and operational level, real-time (or near-real-time) information on troop and force movements may permit more rapid and effective offensive or defensive action. Finally, and as noted, information warfare techniques can go beyond the traditional exploitation of information in the normal range of military operations, to support "information" attacks on political and economic infrastructures. This capability (and reciprocal vulnerability) can only be expected to grow as nations become more and more linked by computer networks.

Limits and Risks. The United States, continuing to seek some technological advantage that corresponds to its traditional way of war, now believes it has found

one in information warfare. However, because information exploitation is a dynamic contest between at least two sides, it limits options and exposes friendly forces to operational vulnerabilities. Further, there are inherent and underlying risks, at national and strategic levels, in reliance upon sophisticated information systems. (None of this is to suggest that the nation should not seek technological advantage, but rather to argue the need to take account of potential *dis*advantages. Unfortunately, emphasis has so far been placed upon the positive aspects of command and control hardware, while doctrinal concerns remain largely ignored.[21] Improvements in the ability to exploit knowledge of an enemy's material factors have not altered the fundamental nature of war as a contest fraught with passions, friction, and uncertainty.)

The first factor limiting options is that manipulation of perceptions can also be applied to one's own commanders, political leaders, and populace. Second, the rapid proliferation of information technologies particularly reduces the ability to achieve surprise.[22] Specifically, U.S. forces will increasingly be observed from space, thereby losing the ability to move large forces undetected, as the coalition did in DESERT STORM.[23] Finally, on the operational level, improved information connectivity and distribution increases the tension between operational security and effective planning. As integration increases, operational security decreases—pointing to a need to develop appropriate controls for the dissemination of information.

Five principal risks can be identified at the national level. First, information technologies have expanded faster than the nation's understanding of the inherent vulnerabilities of the networks and systems that bind the more advanced nations.[24] The risk is that "the threat to national security will most likely break free of traditional boundaries . . . [and] that a future adversary adept at information warfare might be able to cripple all the important financial, transportation, and communications functions of the U.S. without even entering the country."[25] Clearly, there is a great deal more potential for disruption in the domestic and economic arenas than in the past.

Second, the strategic vulnerability of technologically dependent militaries has increased. In the last century, for example, information systems have become so pervasive and thus indispensable that "modern militaries are utterly dependent upon [them] to maintain, deploy, and employ virtually every weapon system in their arsenals."[26] For example, civilian networks, which now account for the vast majority of military communication, electrical power, and military transport, are increasingly susceptible to damage or destruction.[27] Conversely, some originally military assets (notably the Global Positioning System) are now so heavily relied upon in the international civil sector that they probably could not be deliberately restricted or altered to prevent enemy exploitation (even if the U.S. military itself could manage without them) in anything short of general war.

Third, increased emphasis on technology can undercut the ability of the United States to fight in conflicts where technology has little application. Low-technology countermeasures will continue to be developed, and the fact that "crude" forces can defeat high-technology ones was proven during the Vietnam War. Relatedly, increased technological dependence can directly undermine the effectiveness of current forces. The explosion of technology coupled with "the unique nature of many military systems has meant production lines have closed for many front-line weapons systems components. The loss of item manufacturers and material suppliers can affect a weapons system throughout its life-cycle, from design through operational use."[28] The lack of spare parts or increasing lead times to acquire them can reduce overall readiness.

Fourth, there is always the danger that technology gaps will close, sometimes suddenly. Advances breed either duplication by the enemy or effective counters. Moreover, the ability to control the proliferation of military technologies is eroding as they become available in commercial components and systems.

Finally, technological reliance is also increasingly affected by relative economic decline. Decreasing economic strength reduces the numbers and types of weapons that can be purchased. This problem is made worse by the natural upward spiral in the cost of advanced systems, leading to outlays of larger amounts of money for fewer weapons.[29] At the same time, technology extends the time needed to develop new weapon systems, reducing the speed with which they could be replaced in time of war.

Information technologies do act as force multipliers, but is it better to have a larger force with lower technology or a smaller one tied to advanced systems? The larger force is more expensive in terms of maintenance, while the smaller one costs more to procure.[30] This dilemma is apparent in the crisis in recapitalizing the United States military. Understanding the role *and limitations* of information and technology is more important today than ever.

Tools of Planning: The Center of Gravity

Information and technology play critical roles in the conduct of warfare; in effect, they set bounds as to how a conflict will be planned and waged. A planning tool that has been frequently ignored outside of academic settings is the concept of the "center of gravity." It is supposed to help identify principal objectives at each level of war. Unfortunately, the complexities of modern warfare and misconceptions about the concept have produced ambiguity as to its application, and some failures. Moreover, the recent explosion of information technologies has further confused the meaning and application of the center-of-gravity approach.

The "center of gravity" was originally formulated by Carl von Clausewitz in his classic *On War*.[31] "One must keep," he argued, "the dominant characteristics of both belligerents in mind. Out of these characteristics a certain center of gravity develops, *the hub of all power and movement*, on which everything depends. That is the point against which all our energies should be directed. . . . The first principle is that the ultimate substance of enemy strength must be traced back to the fewest possible sources, and ideally to one alone. . . . The first task, then, in planning for a war is to identify the enemy's centers of gravity, and if possible trace them back to a single one."[32] For Clausewitz, the principal, or single, center of gravity was normally the army of the opposing nation. "No matter what the central feature of the enemy's power may be—the point on which your efforts must converge—the defeat and destruction of his fighting force remains the best way to begin, and in every case will be a very significant feature of the campaign."[33] Clausewitz further suggested that armed forces, even divided ones, can be viewed collectively. "The fighting forces of each belligerent—whether a single state or an alliance of states—have a certain unity and therefore some cohesion. Where there is cohesion, the analogy of the center of gravity can be applied. Thus, these forces will possess certain centers of gravity, which, by their movement and direction, govern the rest; and those centers of gravity will be found wherever the forces are most concentrated."[34]

Unfortunately, this emphasis on the armed forces, reflecting Clausewitz's own operational perspective and historical setting, has led to considerable confusion. Although Clausewitz focused on armies, the comprehensive nature of his work suggested the possibility of other centers of gravity. These other centers would be determined by the nature of the conflict and the unique characteristics and aims of the belligerent nations. "We can now see that in war many roads lead to success, and that they do not all involve the opponent's outright defeat. They range from *the destruction of the enemy's forces, the conquest of his territory, to a temporary occupation or invasion, to projects with an immediate political purpose, and finally to passively awaiting the enemy's attacks*. Any one of these may be used to overcome the enemy's will: the choice depends on circumstances."[35] Here Clausewitz transcended his environment and offered a conceptual framework for all levels of war; for the most part, however, he envisioned centers of gravity at the operational level. Nonetheless, they are valuable at the strategic level as an analytical tool. Clausewitz even projected, noting that his thinking was not yet fully developed, that later revisions of his work would show how "this idea of a center of gravity in the enemy's forces operates throughout the plan of war."[36] Certainly, in his published work he identified the army, the capital, alliances, and, for popular uprisings, public opinion and the personalities of leaders as potential centers of gravity.[37]

Technology and the Center of Gravity. With the advent of air power (presented by its prophets Giulio Douhet and "Billy" Mitchell), there began a classic case of the influence of technology upon centers of gravity. The issue arose almost immediately, in the form of debates on the proper selection of targets for the new weapon. Douhet argued in 1921 that technology had altered the nature of warfare, in that aviation offered a unique potential to bomb the enemy heartland; the principal role of aircraft had changed from scouting and aerial combat to long-range bombing. "We can see now . . . [that] war is no longer fought in a series of scattered encounters, no matter how brave or skillful the participants may be. War today is fought by masses of men and machines. So this aerial knight-errantry ought to be supplanted by a real cavalry of the air. . . . What determines victory in aerial warfare is [bomb] firepower."[38] He believed, as some airpower theorists do today, that "airpower is the primary weapon of this strategy because only it can provide the access, mass, persistence, and simultaneity of attack needed to induce paralysis."[39] Technology, then, applied in the choice of targets, drove air strategy. Although Douhet did not offer prioritized objectives or targets that would constitute a center of gravity, he saw cumulative physical destruction of ground targets as the way to defeat an enemy.[40] His rationale rested on a belief in the greater inherent offensive capabilities of air forces relative to armies and navies.

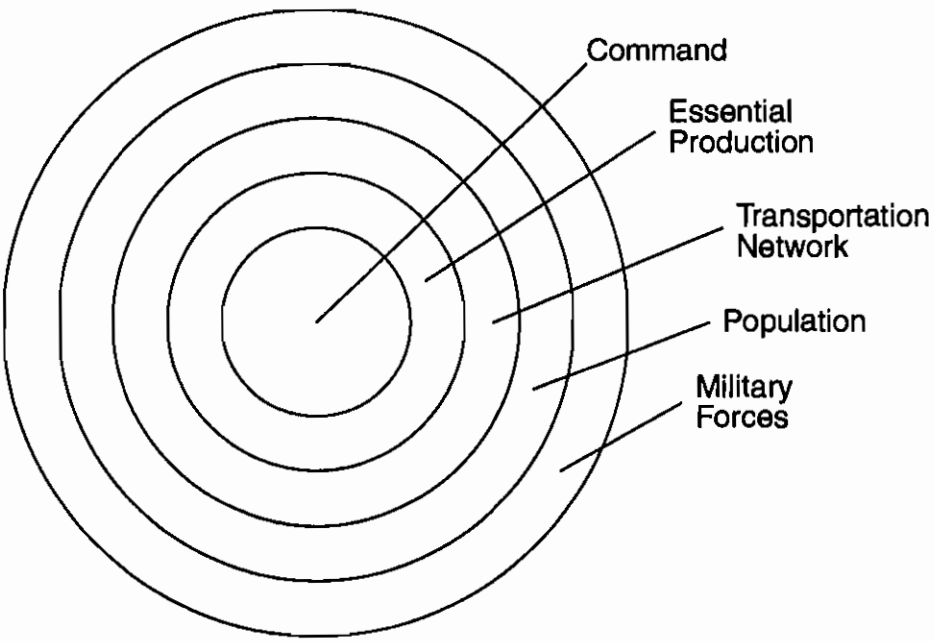
In the United States, in the same period, Brigadier General William Mitchell envisioned a similar future for aviation. Unlike Douhet, however, Mitchell foresaw a continuing need for "pursuit," or fighter, aircraft to engage in aerial contests. Even so, Mitchell argued that the strategic bomber offered a unique means for devastating enemy industrial capabilities. "Heretofore, to reach the heart of a country and gain victory in war, the land armies had to be defeated in the field and a long process of successive military advances made against it. Broken railroad lines, blown up bridges, and destroyed roads necessitated months of hardships, the loss of thousands of lives, and untold wealth to accomplish. Now an attack from an air force using explosive bombs and gas may cause the complete evacuation of and cessation of industry in these places."[41] Mitchell's vision forced a critical debate among the services in the United States, mostly because of his proclamation of the demise of the battleship, but also because it forecast an end to large-scale mobilization of national resources for war.[42] He foresaw an ability to avoid attrition warfare by flying past the ground battle to attack critical industries directly.

In effect, the air power model sees two roles for aviation: to attack the center of gravity directly or, if the center is not vulnerable, to strike critical targets on the periphery—in which case these "peripheral" targets thus assume strategic and operational significance.[43] Positing some form of strategic paralysis or disruption of the will to fight as a goal, the air power model assumes that each

nation has vital targets that are more important than other factors to its capability or desire to fight; a foe should attempt to concentrate all air resources against them.[44] Specifically, modern air power proponents suggest seven specific vital targets: leadership, industry, the armed forces, population, transportation, communications, and alliances.[45] Moreover, in this view, these targets should be seen as dynamic and interrelated; through the destruction or neutralization of various of these elements, paralysis or loss of political will can be induced in an enemy.

Another, but closely related, reflection of the influence of technology upon the center of gravity concept is the command and control model, sometimes called the "five-ring theory." Its originator, Colonel John A. Warden, U.S. Air Force, tested it while developing targeting priorities during the Persian Gulf War. His theory, like the air power model itself, is based upon the ability of aircraft to strike at targets other than the opposing armed forces. Specifically, it suggests that any nation can be seen as a system having five vital components, which can in turn be represented as concentric rings—command, essential production, transportation networks, population, and military forces (Figure 2). Each is part of the center of gravity, and each represents both strengths and weaknesses.[46]

Figure 2
Five-Ring Theory



Source: Warden, "Employing Air Power"

Although rings may be at different levels of development, air power allows one to strike any of them without necessarily hitting enemy armed forces (though defeat of a nation's armed forces may make all of the other rings vulnerable. The model (actually a specialized targeting plan) proposes that it is usually best to attack all of the rings simultaneously.

Information as a Center of Gravity. The conspicuous role of information has led some theorists to believe that information itself has become a center of gravity. Proponents of the five-ring theory argue specifically that it can indeed become one. In Warden's command and control model, information can be a center of gravity if by it we mean information *users* (i.e., under the rubric of command and control). The five-ring model holds, in fact, that leadership, or command and control, is *always* the principal center of gravity:[47] the enemy command structure is the most critical element, because leaders are the only individuals in a country who can negotiate or make concessions.[48]

Although this perception of the role of the enemy command (i.e., to direct forces) is correct, it misses the critical way in which the use of force and the political goals of a nation (to "compel the enemy to do one's will") are linked—through a *tangible* objective, be it the defeat of armed forces, taking of territory, or seizure of possessions.[49] Certainly, intangible factors, such as the will of the leadership, can be influenced by attacks on the enemy command and control elements, but the end is more often achieved in some concrete way.

In practical terms, several difficulties arise from focusing on an enemy's command and control. First, specifically targeting the enemy leadership is problematic, even if one knows its precise location in the first place. Strategies that attempt to decapitate political leadership in order to end a conflict can work only if the likely replacements are of a different stripe than the incumbents. Instances are few in which the death or removal of a specific individual or group of individuals would have led to a prompt capitulation. In fact, while the removal of a given leader may seem desirable, it could result in an even more intransigent leadership.[50] As for communications nodes, the notion that they should *always* be attacked is plainly false. Although it has been suggested that command communications have become both increasingly important and vulnerable, disrupting enemy communications could be counterproductive if they have been yielding valuable intelligence or if the enemy then resorts to communications that are not susceptible to monitoring. But, judging from views prevalent in professional literature, attacking command and control has unfortunately become nearly axiomatic; in practice, commanders and their staffs must be much more calculating. Such attacks may be impossible, incompatible with one's own operations, or unwise.

Another theory of war views the collective enemy as a system.[51] Instead of emphasizing the components of state systems (like the five-ring theory), this model seeks to explain victory in terms of "information dominance"; changes in information processing and targeting "have now converged to enable [information] to achieve overarching effects in the realm of conflict."[52] Greater informational connectivity now permits the exploitation of military elements not directly attacked, its infrastructure, and ties to other subsystems.[53] Using a systems approach focusing on information, and examining nations as entities that attack components of their enemy, this view holds that information becomes the factor on which the outcome of a conflict depends. The implication is that information dominance can be achieved—as it was in the Battle of the Atlantic through the exploitation of cryptologic systems—and that information is an entity to be targeted and exploited.

The point being missed, however, is that the exploitation of information has always been a part of warfare. There may be value in recognizing that increased connectivity may, in theory, make exploitation of information easier, but this does not constitute something fundamentally new. In addition this view does not ascribe to information the defining characteristic of being able, if suppressed, to cause cascading failure, to leave forces incapable of continuing their efforts. No doubt, the exploitation of information can severely hamper the efforts of the enemy; yet victory is achieved—the classicist would argue—not by defeating his information but by beating his armed forces.

Characteristics of a Center of Gravity. Although the center-of-gravity concept has been influenced by information systems and technology, its value still lies in its ability to focus planning efforts. One's initial capabilities affect how the concept is applied. If one is strong, attacking the enemy's center of gravity becomes a viable option, offering direct path to victory; if one is weak, the attempt would be fruitless and most likely debilitating. In that case, one attacks weaknesses to shift the balance gradually until one can strike the center of gravity directly. The first characteristic of a center of gravity, then, is that *it remains the enemy's principal strength*. To weaken a center of gravity is to imperil the enemy's ability to continue the conflict; to destroy the center of gravity is to produce a cascading failure that leads to capitulation. The air power model and the command and control model reflect the overlay of technology upon the center of gravity concept; in those views, aircraft (or electrons) are employed to attack strategic and operational targets whose destruction, it is presumed, leads to the collapse of the center of gravity.[54]

The second characteristic of a center of gravity is that *each enemy has only one of them*, at least at each level of war.[55] In a traditional democratic system, for example, one might expect the will of the people or the cohesion of a coalition to serve as the

strategic center of gravity, while operational and tactical centers would most likely be military forces or supporting infrastructure.[56] Although singular, the center of gravity can change as an operation unfolds or as the corresponding strengths and capabilities of the sides alter. For example, prior to an amphibious landing, the amphibious task force may represent the attacker's center of gravity; once the landing forces are ashore, however, it would presumably shift to the ground troops.

The third characteristic of a center of gravity is that what is the most important one for a given level of war normally *depends on the nature of the war itself*. A war of attrition or of prolonged duration (e.g., Vietnam) tends to de-emphasize tactical or operational achievements, while other types tend to downplay strategic centers of gravity (since in them the strategic goal may be attainable by operational success.)[57]

A fourth characteristic of centers of gravity is that to some extent they are *limited or defined by strategy*. The level of technology, degree of doctrinal adaptation, and the nature of societal values—such as acceptance of casualties versus risk aversion, or more democratic norms versus totalitarian principles—influence the focus of a center of gravity. For the United States, recent aversion to casualties and fear of prolonged conflicts results in a greater emphasis on technology and a lesser willingness to commit forces to operations not deemed in the vital interest. Technology also affects the nature of a war and bounds the means available to attack the center of gravity, while ideological values can also affect the viability of a potential center. A totalitarian regime not reliant on public support, for example, is less susceptible to attacks on the will of the people or public morale than is a democracy.[58]

In summary, a center of gravity is a main source of power or strength which, if destroyed, causes such a debilitating effect as to terminate the war. Even if the command and control functions of an opponent are crippled, one still has to defeat the opponent's armed forces. Accordingly, information is a means or tool, not an end to be pursued in war for its own sake. Information can be either a critical strength (if one side can dominate it) or, and more probably, a critical vulnerability (by creating an indirect path to the center of gravity).

The Misplaced Tool

As we have seen, overwhelming force and technological advantage are not applicable in every conflict. The center of gravity concept, however, can be a useful analytical tool when the traditional American way of war is not practical. Unfortunately, differing service perceptions and the tendency to "refight the last war" continue to obscure the utility of the concept.

Service Perceptions. The United States Marine Corps is a relatively small force accustomed to "forcing entry" into a theater; it naturally prefers to attack where the enemy is weak. Thus, whereas the United States Army views the center of

gravity as an enemy's strength, the Marine Corps looks for it among his weaknesses.[59] The Marine Corps considers the classic idea of a center of gravity as actually dangerous: "Clearly, Clausewitz was advocating a climactic test of strength against strength 'by daring all to win all.' This approach is consistent with Clausewitz' historical perspective. But we have since come to prefer pitting strength against weakness. Applying the term to modern warfare, we must make it clear that *by the enemy's center of gravity we do not mean a source of strength, but rather a critical vulnerability.*"[60]

The United States Navy adopts the perspective of the center of gravity as a source of strength; but with its recent emphasis on littoral warfare, the Navy (not surprisingly) applies it in a manner tied to that of the Marine Corps. That is, naval doctrine seeks "opportunities to access and destroy a center of gravity" *through* critical vulnerabilities.[61] In contrast, the United States Air Force asserts that "successful strategic attack operations depend on proper identification of the enemy's major vulnerabilities—centers of gravity."[62] With an organizational history and outlook different from those of the other services, the Air Force adopts targeting priorities consistent with John Warden's five-ring theory. Aerospace doctrine notes that "against a modern industrialized opponent in a conventional or nuclear war, a center of gravity may be discerned by a careful analysis of the enemy's infrastructure, logistics system, population centers, and command and control apparatus. Against a less industrialized opponent, a center of gravity may be subtle—it could, for example, be the political or material support the enemy obtains from noncombatant allies."[63] As a result, the Air Force tends to adopt the notion of multiple centers of gravity, with each targeting category a "center."

Fighting the Last War. A second factor that obscures the utility of the center-of-gravity concept is the tendency to carry over uncritically lessons learned in the last war. For instance, the Persian Gulf War clearly demonstrated the advantages of integrated weapons and sensors. At the same time, the exposure of the American public and media only to high-technology combat supported an aversion to casualties and an expectation of sophistication that will not be appropriate in all future conflicts. The danger in making this particular war a blueprint for future conflicts is that it reinforces a growing perception that war can be nearly bloodless (for one's own side, that is). For example, the 1991 video footage of missiles striking specific doorways or ventilation shafts not only belied the human cost but also was not representative of the war fought off-camera. In fact, only 6.2 percent of the munitions used in the Kuwaiti Theater of Operations in DESERT STORM were precision-guided.[64]

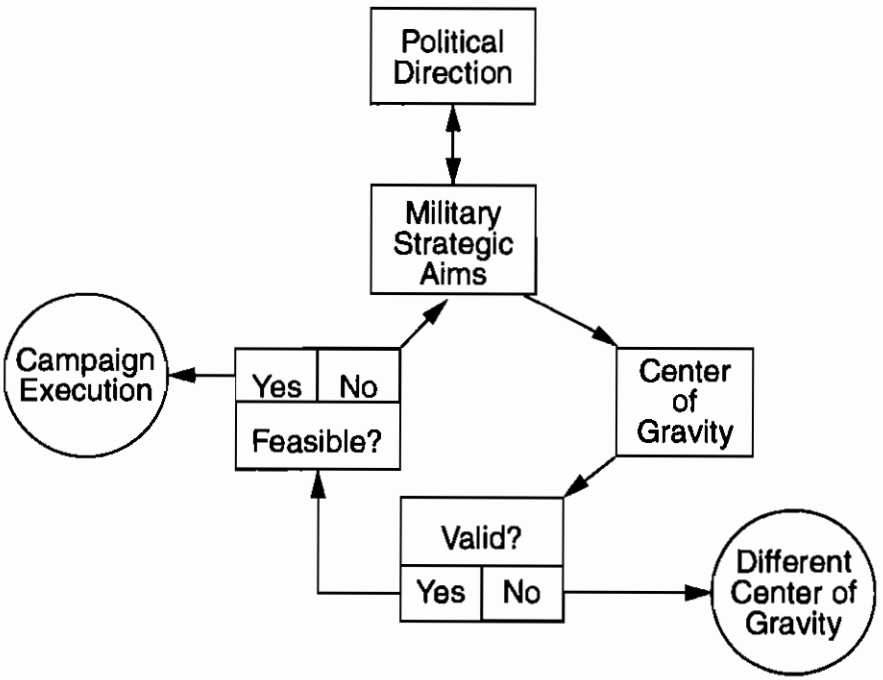
Other reasons that the Gulf war may not be typical of future wars include the unusual world consensus that prevailed, Iraq's passive defense, the absence of a

balanced air-ground-naval adversary, and an unusually good coalition infrastructure.[65] This last is perhaps most critical; without the six months it had to get soldiers, munitions, and other supplies into the theater, and without Saudi Arabia's superb air and port facilities, the coalition might not have been able to keep Iraqi forces out of Saudi Arabia and from thereby changing the very nature, and potential costs, of the war.[66]

Unfortunately, ambiguity as to centers of gravity produced planning that was not optimal. In the Gulf war, the centers of gravity were designated as: leadership and command and control; chemical, biological, and nuclear capability; and forces of the Republican Guard.[67] However, their destruction was not prioritized as befitted their status as centers of gravity but instead was allocated to specific phases and tied to campaign objectives.[68] These objectives were not analyzed as to whether they were the enemy's principal strengths, destruction of which could cause cascading failure—even though they were listed as "strategic targets." In other words, targeting took place prior to selection of a true center of gravity.

Center-of-Gravity Decision Models. If the application of the center-of-gravity concept is complicated by different service perceptions and a tendency to refight

Figure 3
Mendel-Tooke Decision Model

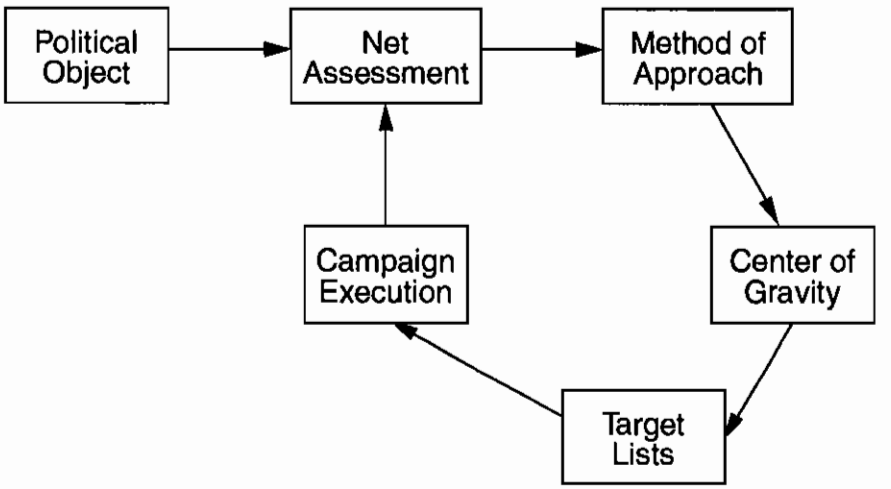


Source: Mendel and Tooke, by permission

the last war, the question of how to apply the concept is similarly murky. William W. Mendel and Lamar Tooke suggest the selection of a center of gravity by a test of validity and feasibility (Figure 3).[69] Their model suggests that a potential center of gravity should be tested against the criterion of whether imposing one's will over it creates a "deteriorating effect that prevents our foe from achieving his aims and allows the achievement of our aims."[70] Feasibility, on the other hand, considers whether one has the capability to dominate the enemy's center of gravity. As a framework for selecting an operational center of gravity, the Mendel-Tooke model leaves the issues of definition, mission, and target development unresolved. One way to address this problem is both to integrate the various service perspectives and to recognize the potential need for a more indirect approach. In addition, the relationship between the center of gravity and target development can be systematized.

Such an approach is demonstrated in Figure 4. Here, a traditional "net assessment" between forces provides a starting point for a campaign or operational plan. The assessment suggests a decision as to whether one's strength or capabilities permit attacking the enemy center of gravity directly, at the outset. If not, an indirect path to the center of gravity through critical vulnerabilities can be followed. Once it has been determined whether to attack the center of gravity or critical vulnerabilities, target lists can be developed. Since the relative strengths and capabilities of both forces change over the course of a conflict, the model calls for reassessments, which restart the cycle.

Figure 4
Center of Gravity Flow Chart



This method acknowledges different service perspectives but also reflects the anticipated initial strength of the forces. It incorporates the innovative Mendel-Tooke concept of a feasibility test by including strategic aims in the net assessment and by taking account of initial strength. It also expands the concept of a validity test by placing determination of the center of gravity ahead of the creation of target lists. Finally, it reflects the need to reassess net force capabilities cyclically in order to modify the approach or change the center of gravity if required by circumstances or new evidence.

Fighting Better

The American way of war relies on information exploitation and advanced technology. However, the limitations of these tools in various types of conflicts must be considered. A number of factors limit effective planning; they can, in part, be overcome by understanding the role of a center of gravity. Unfortunately, there is a tendency to mistake the role of information in warfare and to overestimate the value of technology. To understand how the United States can fight better in future wars, its military must understand the influence of these factors on command and control and the conduct of war.

The role of information itself is not changing, although improved integration of information has enhanced some aspects of decision-making and target acquisition. There is a growing need for improved systems and methods to monitor and control information flow at the appropriate command levels. The complexity and quantity of information already requires formidable processing to turn data into usable information. The sheer quantity of information that can be delivered to an operational commander necessitates filters to reduce it to a level that can be assimilated.[71] How much can be managed depends upon the intellectual capability and personality of the commander and his staff, but future systems must integrate information, not simply perform more analysis.[72] Unfortunately, any filtering system involves setting limits as to what will be seen and what will be given to other levels for review or analysis; this creates the danger of either overwhelming other links in the chain of command or depriving them of information that may be critical. The key therefore is not merely to make all information available but to categorize appropriately the information required for a given level of warfare.[73]

In addition, the changes in command relationships created by new communications capabilities should be recognized. One of the principal tenets of command is centralized control with decentralized execution; new information technologies, however, are eroding this relationship. Senior commanders, with a real-time picture of the battlefield, will be tempted to interfere in lower-echelon decisions. Another effect may be the stifling of initiative in

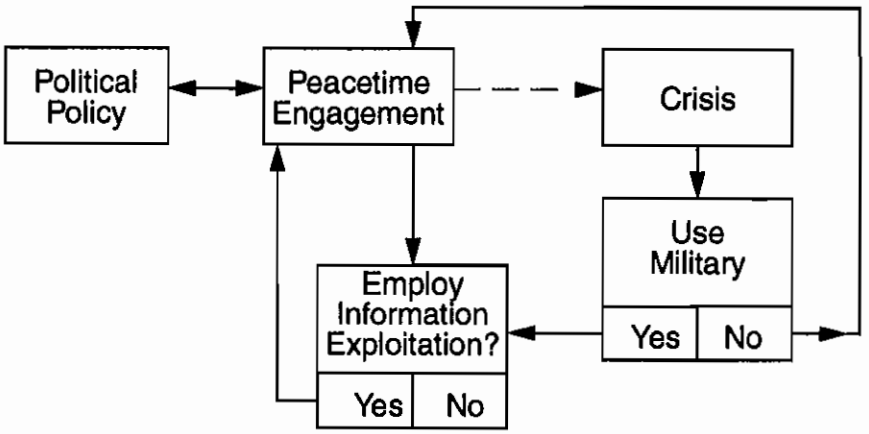
subordinate commanders; even subordinates not required to coordinate details with senior commanders may be inclined to do so simply because the communications means are available. This could compromise initiative and undermine the effectiveness of command.

A second factor that could limit the ability of the United States to fight better is excessive reliance on technology. The risks of technology—including increased vulnerability, decreased effectiveness of preexisting forces, and the possibility of proliferation—must in the future be balanced against the nature of conflicts and decreasing defense budgets. Also, to exploit fully new technologies there is a need for an *integrated* doctrine, one that is adaptable for training purposes. In addition, systems development requires continued standardization and greater emphasis on information security and counter–command and control techniques. As a result, in the development and integration of information systems, emphasis should be placed on security and redundancy.

Information warfare, as an outgrowth of information integration, offers a promise of improved capabilities. The usefulness of information *exploitation*, in contrast, is limited by the dynamic nature of war and because its technologies often fall outside the military's purview. As a result, coordination between the Department of Defense and agencies that will actually execute information warfare needs to be established.

Figure 5 represents a simplified method for determining whether information exploitation should be used in a given instance. This chart implies a need for continuing assessment as to whether to apply information warfare techniques, and also the necessity to select an appropriate agency for execution of the mission.

Figure 5
Decision for Information Exploitation



Although the United States now possesses a strong military with numerous technological superiorities, the American way of war threatens to limit its options in future planning and in the execution of war. The nation needs to reconcile the role and limitations of information and technology in the way it conducts war. In addition, the United States military should reconcile the utility of the concept of center of gravity with the various service definitions and perceptions of the term. Doing so will revive a useful analytical tool. It will also produce a new American way of war better fitted to the challenges the nation is already facing.

Notes

1. For a historical analysis, see Russell F. Weigley, *The American Way of War: A History of United States Military Strategy and Policy* (Bloomington: Indiana Univ. Press, 1977).

2. Harry G. Summers, Jr., *On Strategy: A Critical Analysis of the Vietnam War* (New York: Dell Publishing, 1984), pp. 177–9. Colonel Summers contends that the United States failed to identify the North Vietnamese Army as the principal center of gravity and as a result lost the war. In his sequel on the Gulf war he credits the United States with correctly identifying Iraqi strengths and weaknesses. Unfortunately, any examination of the concept of a center of gravity suggests an analytical problem: if one wins the war, there is a tendency to assume that all one's actions were rational and correct.

3. Donald E. Ryan, Jr., "Implications of Information-Based Warfare," *Joint Force Quarterly*, Autumn/Winter 1994–95; p. 114.

4. Office of the Joint Chiefs of Staff, *DOD Dictionary of Military and Associated Terms*, Joint Publication 1-02 (Washington, D.C.: 1984), p. 188.

5. Office of the Joint Chiefs of Staff, *Doctrine for Joint Operations*, Joint Publication 3-0 (Washington, D.C.: 1995), p. III-20.

6. The author is indebted for this insight to Timothy J. Keppler, "The Center of Gravity Concept: A Knowledge Engineering Approach to Improved Understanding and Application" (unpublished paper, U.S. Army Command and General Staff College, Fort Leavenworth, Kans.: June 1995, p. 45). Keppler identified common elements of centers of gravity that he used to develop an automated model, the U.S. Army War College "Center of Gravity Determination Assistant." This model uses knowledge-engineering techniques to establish parameters for personal computer software.

7. Owen E. Jensen, "Information Warfare: Principles of Third-Wave War," *Airpower Journal*, Winter 1994, p. 38; and Marshall McLuhan, quoted in "Information Warfare: A Two-Edged Sword," *RAND Research Review*, Fall 1995, p. 4.

8. Department of Defense Directive S-3600.1, "Information Warfare" (Washington, D.C.: 1996) offers this recently declassified definition of information warfare. The directive specifies that command and control warfare is a subset of information warfare. Milan N. Vego ("Operational Leadership," unpublished paper, U.S. Naval War College, Newport, R.I.: July 1995, p. 11) similarly defines information warfare as "a series of actions conducted in support of national security strategy aimed to maintain a decisive advantage by attacking an adversary's information infrastructure through exploitation, denial, and influence, while protecting friendly information systems."

9. Joint Publication 1-02.

10. Martin C. Libicki, *What Is Information Warfare?* (Washington, D.C.: National Defense Univ., 1995), p. 97.

11. See, for example, Alvin Toffler and Heidi Toffler, *War and Anti-War: Survival at the Dawn of the 21st Century* (New York: Warner Books, 1993).

12. Ibid.

13. William S. Lind et al., "The Changing Face of War: Into the Fourth Generation," *Marine Corps Gazette*, October 1989, p. 23.

14. Ibid.

15. Ibid.

16. Thomas X. Hammes, "The Evolution of War: The Fourth Generation," *Marine Corps Gazette*, September 1994, p. 35.

17. John J. Arquilla and David F. Ronfeldt, "Cyberwar and Netwar: New Modes, Old Concepts, of Conflict," *RAND Research Review*, Fall 1995, p. 8. These authors provide the definitions of Netwar and Cyberwar used by Hammes.

18. Ibid., p. 9. In contrast to Netwars, economic wars target the production and distribution of goods, while political wars target leadership and government institutions.

19. Andrew F. Krepinevich, "Cavalry to Computer: The Pattern of Military Revolutions," *The National Interest*, Fall 1994, p. 30.

20. Ibid., p. 31.

21. Jensen, p. 38.

22. James R. Wolf, "Implications of Space-Based Observation," *Military Review*, April 1994, p. 75.

23. Ibid., p. 84.

24. David C. Gompert, "Keeping Information Warfare in Perspective," *RAND Research Review*, Fall 1995, p. 6.

25. John T. Correll, "Signs of a Revolution," *Air Force Magazine*, August 1995, p. 2.

26. Ryan, p. 114.

27. "Information Warfare: A Two-Edged Sword," *RAND Research Review*, p. 4.

28. "Defense Base Forecast," *National Defense*, October 1995, p.5.

29. Paul Kennedy, *The Rise and Fall of the Great Powers* (New York: Vintage Books, 1989), p. 522.

30. Charles Swett, review of *War and Anti-War* by Alvin Toffler and Heidi Toffler, *Special Warfare*, January 1995, p. 30.

31. The most comprehensive examination of Clausewitz can be found in Michael I. Handel, *Masters of War: Sun Tzu, Clausewitz and Jomini* (London: Frank Cass, 1992).

32. Carl von Clausewitz, *On War*, Michael Howard and Peter Paret, eds. and trans. (Princeton, N.J.: Princeton Univ. Press, 1984), pp. 595–6, 617–9.

33. Ibid., p. 596.

34. Ibid., pp. 485–6.

35. Ibid., p. 94. (Emphasis original.)

36. Ibid., p. 486.

37. Ibid., p. 596.

38. Giulio Douhet, *The Command of the Air*, trans. Dino Ferrari (New York: Coward-McCann, 1942), pp. 43–4.

39. Jason B. Barlow, "Strategic Paralysis: An Air Power Strategy for the Present," *Airpower Journal*, Winter 1993, p. 5.

40. Ibid., p. 51.

41. William Mitchell, *Winged Defense* (New York: G.P. Putnam's Sons, 1925), pp. 5–6.

42. Ibid., pp. 8–9.

43. The author is indebted to Lt. Col. Thomas A. McCarthy, USAF, for this insight, to be found in his unpublished paper "Air Power and the Center of Gravity," Naval War College, Newport, R.I.: June 1995, pp. 3,9 (available from the Defense Technical Information Center, Springfield, Va.).

44. Barlow, p. 9.

45. Ibid., p. 10.

46. John A. Warden, "Employing Air Power in the Twenty-First Century," in *The Future of Air Power in the Aftermath of the Gulf War*, eds. Richard H. Shultz, Jr., and Robert L. Pfaltzgraff, Jr. (Maxwell AFB, Ala.: Air Univ. Press), p. 64.

47. Ibid., p. 65.

48. Ibid.

49. Clausewitz, p. 101.

50. Steven Metz and Frederick M. Downey, "Centers of Gravity and Strategy Planning," *Military Review*, April 1988, p. 30. See also Bruce A. Ross (Lt. Cdr., USN), "The Case for Targeting Leadership in War," *Naval War College Review*, Winter 1993.

51. John Arquilla, "The Strategic Implications of Information Dominance," *Strategic Review*, Summer 1994, p. 28. Arquilla holds that when systemic elements are analyzed, "a practical approach to employing information dominance against centers of gravity suggests itself."

52. Ibid., p. 27.

53. Ibid., p. 28.

54. It can also be argued that the technological nature of modern war often requires indirect attacks first to gain air superiority, since "the enabler for all subsequent missions, be they air missions or ground missions, is air superiority." (McCarthy, p. 10, q. v.).

55. Lisa Bennett and Bruce Niedrauer, "Center of Gravity," *Military Intelligence Professional Bulletin*, April-June 1995, p. 25. The authors similarly believe that "the nature of a center of gravity may vary. At the national level the center of gravity is often abstract. It may be national will and public opinion, key individuals, massed armor or artillery units, specific elite units, or air or naval power."

56. William W. Mendel and Lamar Tooke, "Operational Logic: Selecting the Center of Gravity," *Military Review*, June 1993, p. 25. The authors argue that "aims or objectives established at the operational or tactical levels should contribute to our ability to impose our will (such as destroy, defeat or delay) over the center of gravity at the next higher level of war." I agree with this as an ideal but suggest that it is highly dependent upon the nature of the conflict.

57. In Book One, chapter 2, of *On War*, Clausewitz observes, "Since war is not an act of senseless passion but is controlled by its political object, the value of this object must determine the sacrifices to be made for it in *magnitude* and also in *duration*. Once the expenditure of effort exceeds the value of the political object, the object must be renounced and peace must follow" (Clausewitz, p. 92, emphasis original). This implies that there are only two ways to modify the commitment to a political objective: to increase the amount of force employed vis-à-vis an opponent or prolong the conflict in the hope of achieving advantage at a later time.

58. Metz and Downey, p. 29.

59. See U.S. Army Field Manual 100-5, *Operations* (Washington, D.C.: 20 August 1982), which asserts, "The center of gravity is the hub of all power and movement upon which everything depends. It is that characteristic, capability, or location from which enemy and friendly forces derive their freedom of action, physical strength, or will to fight. The essence of operational art lies in being able to mass effects against the enemy's main source of power—his center of gravity, which he seeks to protect." In addition, FM 100-5 suggests, "At any given time, however, a center of gravity may not be immediately discernible. For example, the center of gravity might concern the mass of enemy units, but that mass might not yet be formed. Additionally, the center of gravity may be abstract, such as the enemy's national will or an alliance structure, or concrete, such as strategic reserves, C2, or industrial bases and LOCs [lines of communication]." Cf. U.S. Marine Corps Fleet Marine Force Manual (FMFM) 1, *Warfighting* (Washington, D.C.: Mareh 1989), p. 85.

60. FMFM 1, endnote 28. (Emphasis added.)

61. Department of the Navy, Naval Doctrine Publication (NDP) 1, *Naval Warfare* (Washington, D.C.: March 1994), p. 35.

62. Department of the Air Force, Air Force Manual (AFM) 1-1, Vol. II, *Basic Aerospace Doctrine of the United States Air Force* (Washington, D.C.: March 1992), p. 151.

63. Ibid. AFM 1-1 cites Col. John A. Warden III, USAF, *The Air Campaign: Planning for Combat* (Washington, D.C.: National Defense Univ. Press, 1988), pp. 40–59.

64. Eliot A. Cohen, ed., *Gulf War Air Power Survey*, Vol. II, Part 2 (Washington, D.C.: 1993), p. 206. Of the total of 222,479 air-launched munitions used in the Kuwaiti Theater of Operation, only 12,854 were precision-guided. Of this small number, a significant portion (AGM-114 Hellfires for instance) were likely employed in tactical roles, further decreasing the percentage of smart weapons employed in a strategic capacity.

65. The author is indebted for this insight to H.Z. Zeigler (Cdr., USN); see his "Lessons Learned from the Gulf War," unpublished paper, Naval War College, Newport, R.I.: 1992 (available from the Defense Technical Information Center, Springfield, Va.).

66. Robert Denny, "America's Might in the Gulf War," *Retired Officer Magazine*, February 1996, p. 35.

67. Cohen, p. 79.

68. Ibid., pp. 78–9. Centers of gravity and operational campaign objectives were originally specified in the Combined Operations Plan for Offensive Operations to Eject Iraqi Forces from Kuwait, and in a then-classified (U.S.-only) document, USCINCCENT OPORD 91-001.

69. Mendel and Tooke, p. 5.

70. Ibid.

71. W. B. Cunningham and M. M. Taylor, "Information for Battle Command," *Military Review*, November 1994, p. 83.

72. Morris J. Boyd and Michael Woodgerd, "Force XXI Operations," *Military Review*, November 1994, p. 19.

73. These observations assume, of course, a hierarchical organization. For a different approach to the issues of modern communications, command relationships, and initiative, see John W. Bodnar (Capt., USNR, Ret.) and Rebecca Dengler (2nd Lt., USMC), "The Emergence of a Command Network," *Naval War College Review*, Autumn 1996.

Ψ